Chapter 5

Local Area Networks

5.1 Introduction

Local area network, LAN, can be used to interconnect computers, terminals, printers, etc, located within a building or a small set of buildings. While long-haul networks use the public telephone network for economic reasons, LAN designers usually lay their own high-bandwidth cables. Not being forced to optimize bandwidth, a LAN can use simple access algorithms.

5.2 Carrier-Sense Multiple Access Networks (Ethernet)

Ethernet is a LAN access scheme developed by the Xerox Corporation. It is based on the assumption that each local machine can sense the state of a common broadcast channel before attempting to use it. The technique is known as carrier-sense multiple access with collision detection (CSMA/CD). Fig.5.1 illustrates the bit field format for the Ethernet for which:

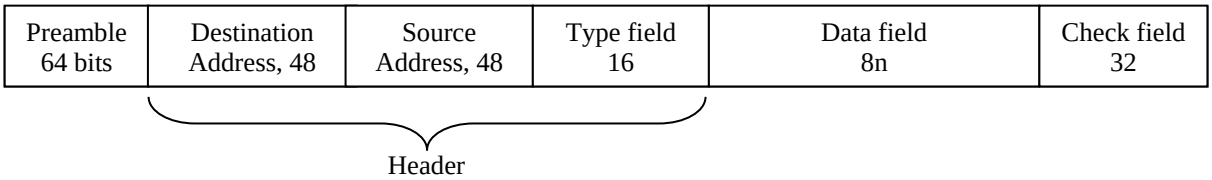


Fig.5.1 Ethernet Bit Field Specification

- The maximum packet size is 1526 byte (where a byte is 8 bits) as:
  - 8-byte preamble
  - 14-byte header
  - 1500-byte data
  - 4-byte parity

- The minimum packet size is 72 bytes consisting of:
    - 8-byte preamble
    - 14-byte header
    - 46-byte data
    - 4-byte parity
- The minimum spacing between packets is 9.6 μs.
- The preamble contains a 64-bit synchronization pattern of alternating 1's and 0's ending with two consecutive ones (i.e., 1,0,1,0,1,0,1,0,…,1,0,1,0,1,0,1,1).
- The receiving station examines a destination address field in the header to see if it should accept a particular packet.
- The source address is the address of the transmitting machine.
- The type field determines how the data field is to be interpreted (e.g., data encoding, encryption, message priority, and so).
- Data field is an integer number of bytes from a minimum of 46 to a maximum of 1500.
- The parity check field is added for error detection.

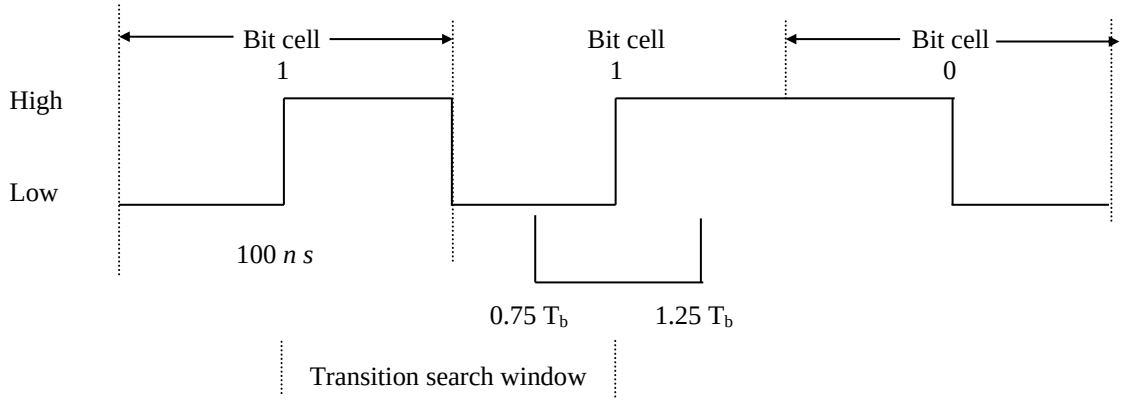


Fig.5.2 Ethernet Manchester PCM Format

Fig.5.2 illustrates a 10 Mbps data stream with Manchester PCM formatting where each bit position contains a transition. Therefore, the presence of data transitions denotes (to all listeners) that the carrier is present. If a transition is not seen between 0.75 and 1.25 bit times since the last transition, the carrier has been lost, indicating the end of a packet.

The Ethernet multiple access with collision detection, CSMA/CD, defined the following user action or response:

1- Defer: The user must not transmit when the carrier is present or within the minimum packet spacing time.
2- Transmit: The user may transmit if not deferring (when the carrier is not present until the end of packet) or if a collision is detected. If a transition is not seen between 0.75 and 1.25 bit times since the last transition, the carrier has been lost, indicating the end of a packet.
3- Abort: If a collision is detected, the user terminates packet transmission and transmits a short jamming signal to ensure that all collision participants are aware of the collision.
4- Retransmit: The user must wait a random delay and then attempt retransmission.
5- Backoff: The delay before the ^{n}th attempt is a uniformly distributed random number from 0 to 2^n-1 for $0 < n < 10$ of the unit-time equivalent to 512 bits (51.2 μs).

5.3 Token-Ring Networks

5.3.1 Comparison:

- The CSMA/CD network consists of a cable onto which all stations are passively connected.
- A ring network consists of a series of point-to-point cables between consecutive stations. The interfaces between the ring and the stations are active rather than passive as indicated in Fig.5.3.

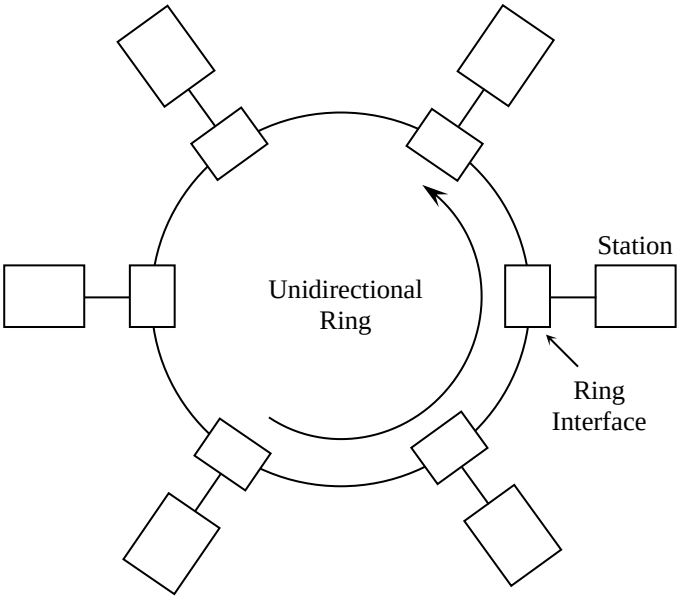
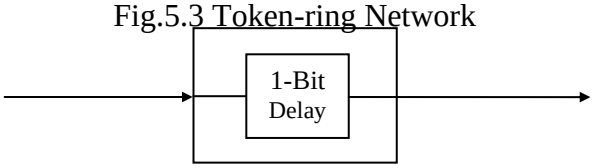


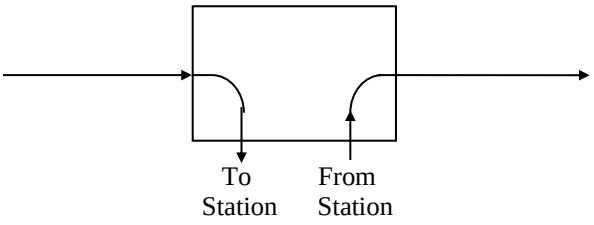
Fig.5.3 Token-ring Network

5.3.2 Interface Modes:

- Listen mode: The input bits are copied to the output with a delay of one bit time.
- Transmit mode: In Fig.5.4 the connection is broken so that the station can enter its own data onto the ring.



(a) Interface listen mode



(b) Interface transmit mode

Fig.5.4 Listen and Transmit Modes

5.3.3 Token:

The token is defined as a special bit pattern. For example, 8-bit taken is: 1 1 1 1 1 1 1 1 which circulates on the ring whenever all stations are idle.

5.3.4 Bit Stuffing:

Bit stuffing is used to prevent the token pattern from occurring in the data. A bit stuffing algorithm would insert a zero into the data stream after each sequence of seven consecutive ones. The receiver would use a similar algorithm to ignore it.

5.3.5 Token-Ring Operation:

- A station monitors the token appearing at the interface. When the last bit of the taken appears, the station invert it (e.g., 1 1 1 1 1 1 1 0). The station then breaks the interface connection and enters its own data onto the ring.
- There is no limit on the size of the packets. As bits come back around the ring, they are removed by the sender.
- After transmitting the last bit of message, the station must regenerate the token. After the last data bit has circled the ring and has been removed, the interface is switched back to the listen mode.

5.3.6 Contention:

Contention is not possible with a Token-ring system since there is only one token. During heavy traffic, the next station requiring service will see the token and remove it. Thereby, the permission to transmit rotates smoothly around the ring without contention.

5.3.7 Propagation Length:

A major design parameter in ring network is the propagation length of a bit. If the data rate is R Mbps, a bit is emitted every $1/R$ microseconds. Since the propagation rate along a typical coaxial cable is 200 meter/microsecond, each bit occupies $200/R$ meters on the ring.

5.3.8 Example:

If an 8-bit token is to be used on a 5 Mbps token-ring network, calculate the minimum propagation distance d_P needed for the ring circumference. Assume that the propagation velocity v_P is 200 meter/microsecond.

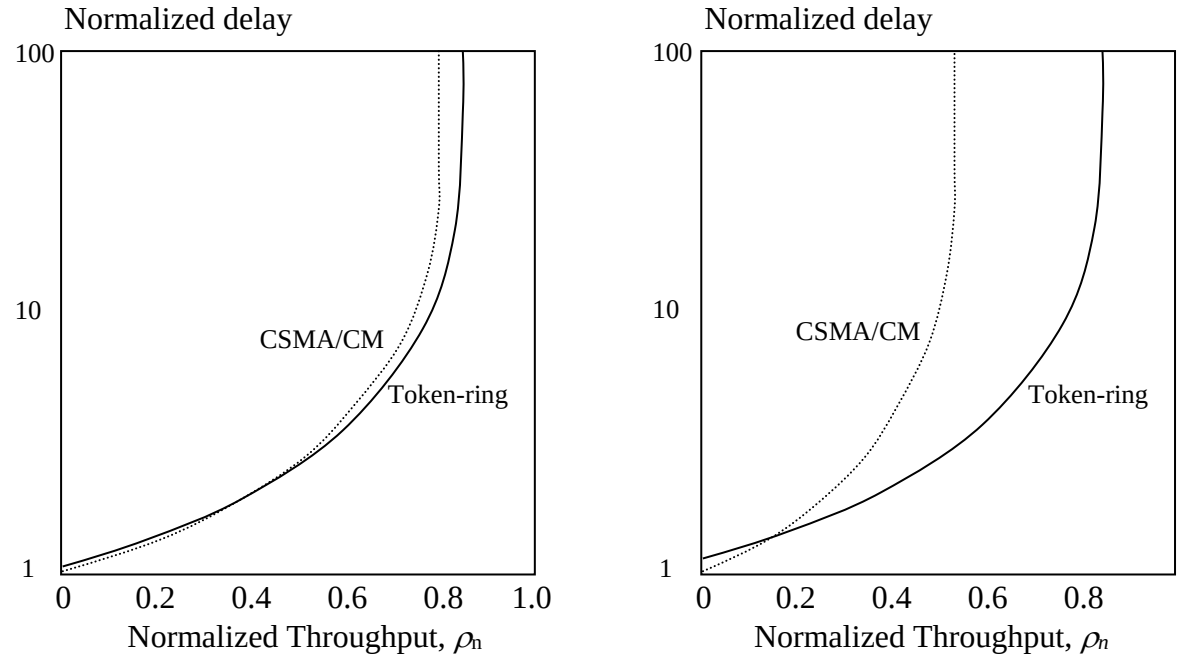
Time to emit one bit is given by: $t_P = \frac{1}{R} = \frac{1}{5x10^{-6}}$ sec

Time to emit one 8-bit Token ring: $t_P = \frac{8}{5x10^{-6}}$ sec

Propagation distance of Token ring: $d_P = t_P \cdot v_P = \frac{8}{5}\mu\text{sec}\, x200\ meter / \mu\text{sec} = 320$ *meters*

5.4 CSMA/CD & Token-ring Networks Comparison

Fig.5.5 compares the delay-throughput characteristics of a CSMA/CD network to token-ring network. The comparison is made for 50 stations, 1000 bits average packets, 2km cable length, and the header length is 24 bits.



(a) Transmission rate is 1 Mbps (b) Transmission rate is 10 Mbps

Fig.5.5 Delay-throughput Performance Comparison